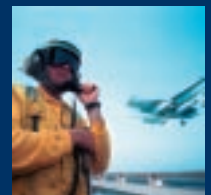


National Center  
for Excellence  
in Metalworking  
Technology

# NCEMT: ANNUAL REPORT: 2000

Ensuring Navy Readiness Through  
Affordable Metalworking Technologies



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The U.S. Navy Manufacturing Technology (MANTECH) Program is committed to the development

and dissemination of world-class manufacturing solutions for the defense industrial base. To accomplish our mission, we are assisted by Centers of Excellence where the nation's best and brightest come together to extend the limits of technology and service.

This year, I am pleased to congratulate the National Center for Excellence in Metalworking Technology (NCEMT) for its outstanding record of accomplishment. The NCEMT, operating under a new five-year, competitively awarded contract, leads the way in the acquisition, evaluation, development, and transfer of metalworking advancement.

Through the challenges ahead, we are confident the NCEMT will serve our nation well. As we enter the 21<sup>st</sup> Century, be assured the NCEMT will further the MANTECH Program's objective to maintain the readiness of U.S. warfighters—affordably and efficiently.

Sincerely,

Steven M. Linder

Director  
Manufacturing Technology  
(MANTECH) Program  
Office of Naval Research



This year, as the United States Navy celebrates the 100<sup>th</sup> anniversary of its first submarine, we

join in saluting the dedicated men and women of the world's greatest Submarine Force—past and present—for their service and sacrifice. Since the USS Holland (SS 1) was commissioned in 1900, American submarine pioneers have forged an impressive legacy of creating, improving, and implementing successful new technologies.

The NCEMT, supporting the development of world-class manufacturing solutions for the Navy and the Defense Department since 1988, joins the national commemoration with pride and humble satisfaction in its contributing role.

It is the ongoing commitment of the NCEMT to support the Navy and other services in their readiness goals. To advance the development of reliable, affordable technology that will perform at a moment's notice, the NCEMT continues to deliver comprehensive metalworking solutions. Technology is the key. Technology for submarines, ships, aircraft, and missiles/

ordnance. Technology that rapidly and effectively meets U.S. warfighters' diverse needs. Technology produced in the most efficient manner, achieving significant savings through reduced acquisition costs and overall life-cycle costs.

There are no second chances in defense. The NCEMT applies a get-it-right-the-first-time directive to each project and delivers manufacturing practices that reduce risk in fielding new weapons systems.

Many of the projects showcased in this annual report are being undertaken in partnership with government and industry through numerous alliances. We appreciate their confidence in our abilities and are pleased that the NCEMT has become a strong national resource for developing and disseminating leading-edge, cost-effective technologies.

As we enter the new millennium, we are especially proud to be part of a great U.S. engineering heritage and strive to honor—through continued hard work and innovation—those who have proceeded us.

Please feel welcome to contact me with your questions or comments; I look forward to providing you with information about the NCEMT and the innovative metalworking solutions that we can offer your organization.

Sincerely,

Richard J. Henry

Program Director  
National Center for Excellence



# State of the NCEMT

Achieving world-class excellence in metalworking technology: initially a goal, now a promise fulfilled. The National Center for Excellence in Metalworking Technology (NCEMT), established by the Navy Manufacturing Technology (MANTECH) Program in 1988, has lived up to the excellence specified in its name. Early in its history, the NCEMT established its reputation as the nation's premier resource for developing and disseminating affordable, advanced metalworking technologies.

In 2000, following a competitive selection process, the Office of Naval Research awarded a new five-year contract to the NCEMT. This action is a strong testimony to the U.S. Navy's confidence in and satisfaction with the NCEMT, to high-caliber work responsibly managed, and to its outstanding record of accomplishment.

The NCEMT has consistently delivered superior manufacturing solutions to Naval and Department of Defense (DOD) challenges.

Today, the U.S. Navy's Surface Fleet, the world's most capable, is benefiting from the NCEMT's recommendations for lighter-weight, higher-performance steels that can now be produced at considerably lower cost by U.S. manufacturers.

Missiles will have extended range, improved thrust, faster rates of climb, reduced fuel consumption, and greater payloads because the NCEMT discovered a better way to form nickel-based single crystal alloys.

Turbine powered aircraft, like the V-22 Osprey, will have improved

performance at lower cost because the NCEMT optimized the manufacture of powder metal isothermally forged Udimet 720.

Combat vehicle design and fabrication will be simpler and more efficient because the NCEMT enabled the use of advanced lightweight materials and friction stir welding.

Further, brake linings for anti-slack devices and hydraulic winch components that once had to be replaced on the Navy's Underway Replenishment ships after only 85 hours of service now last for five years. Until the NCEMT helped optimize the casting of a new wear-resistant composite for the linings, the average operating cost for brakes was \$250 per hour. Now, the cost is just \$18 per hour.

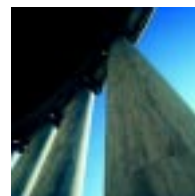
The Navy and its suppliers have ready access to the NCEMT's Atlas of Formability, an extensive database that provides key information such as flow behavior and microstructural evolution for 144 engineering materials commonly used in defense applications. Use of Atlas data leads to quicker process development and faster time to deployment. More than 4,000 requests for data have already been satisfied; the Atlas is available at [www.ncemt.ctc.com](http://www.ncemt.ctc.com). Cost savings are substantial. For example, one turbine engine

supplier has reduced its forging process development costs by 60 percent.

When the Navy needed a medium-caliber barrel that would enable the use of high-impetus ammunition that could exceed 200 rounds, the NCEMT met the challenge. The NCEMT designed, fabricated and tested a modified geometry baseline barrel and a Ta-10W-lined barrel, which completed a Schedule A endurance test at 500 shots per minute—marking the first time this has been achieved for any medium-caliber barrel with high-impetus ammunition.

Proud of its strong record of performance on projects such as these, the NCEMT is poised to begin a new era of service to the Navy. This annual report spotlights several of the projects currently under way at the NCEMT.

Naval readiness and superiority continue to be bolstered by NCEMT-led innovation. Technology enhancement helps keep U.S. warfighters ready for duty at a moment's notice. Technology development at the NCEMT will continue to strengthen the Defense Industrial Base thanks to a highly experienced professional staff that can rapidly and effectively transition science and technology to meet or exceed stringent cost-and-performance standards. ●





# Ensuring Navy Readiness Through Affordable Metalworking Technologies



Achieving readiness objectives. Reducing defense costs. The NCEMT is solving critical defense challenges by delivering reliable, affordable metalworking solutions to the civil-military industrial base.

To achieve its goals, the NCEMT has developed state-of-the-art capabilities in advanced materials testing, process development, technology transition and deployment, training, and education for advanced metalworking technologies.

One of MANTECH's Centers of Excellence, the NCEMT specializes in metalworking manufacturing technologies,

materials, and related processes. Clients from both the defense and commercial industries seek out the NCEMT's expertise.

## **Responding to Client Needs**

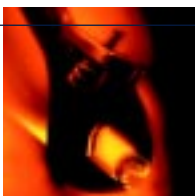
The NCEMT applies broad-based expertise to satisfy increasingly stringent cost and performance standards. Projects must concurrently incorporate the Navy and DOD requirements for life-cycle cost reduction, design flexibility, improved performance, and process optimization.

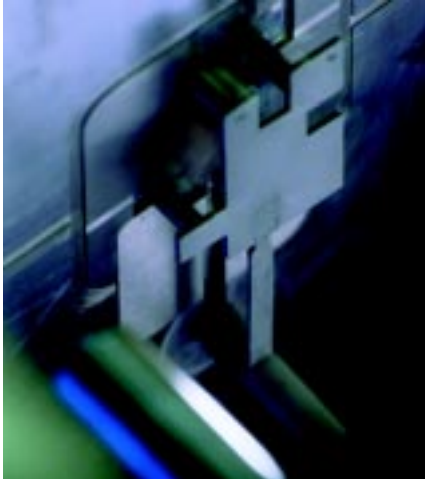
The NCEMT's professional staff strives to develop solutions that reduce production costs while improving quality, reconfigure

products for multiple uses, and enhance availability. Working with its partners within the military-civil industrial base, the NCEMT has been successful in transitioning science and technology applications to help maintain critical readiness objectives.

## **Delivering World-Class Solutions**

The methods by which the NCEMT addresses projects are as cutting-edge as its inventions. For example, the NCEMT has taken the Rational Product & Process Design® (R-P²D®) model to a new level. This methodology ensures that product design and process design occur simultaneously. This enables the development of





cost-effective products that deliver optimum performance. In addition to focusing advanced materials testing and computerized analysis techniques, R•P•D® incorporates environmental considerations in product and process design to minimize adverse environmental impact throughout a product's life cycle.

R•P•D® dramatically reduces or eliminates the need for trial-and-error methods of prototyping. As a result, R•P•D® can be used quickly and efficiently to develop product and process specifications for virtually any type of material and manufacturing process. These

capabilities are particularly important in satisfying the critical need for rapid insertion of new technology in response to unforeseen threats.

#### **Demonstrating Excellence**

Demonstration facilities serve as a key link between computer simulation and the production floor. Clients appreciate the opportunity to view sheet metal forming, wire drawing, forging, semi-solid metalworking (SSM), powder metal compaction, powder injection molding, and welding at the NCEMT's Johnstown, Pennsylvania plant. Demonstration facilities also provide a cost-effective means of

testing, evaluating, and refining metalworking processes.

In addition to improving performance and lowering cost, reducing risk is critical. By helping the U.S. defense industrial base to incorporate proven, advanced technologies into its manufacturing process, the NCEMT helps reduce risk in fielding weapons systems. In turn, the U.S. Navy can affordably, confidently meet warfighter's needs—today and tomorrow. ●

# Integrated Project Teams



The philosophy is historic. A team approach to problem resolution encourages expression and incorporation of the best and brightest ideas.

To achieve the best and most effective metalworking solutions, the NCEMT employs Integrated Project Teams (IPTs). Drawing from a broad range of backgrounds, IPTs include representatives from the U.S. Navy, the Department of Defense, industry, and academia.

The process thrives because of the capability and commitment of the individuals on the teams. Carefully selected professionals who join IPTs to address a specific technology challenge take pride in pushing the envelope of technological and scientific advancement.

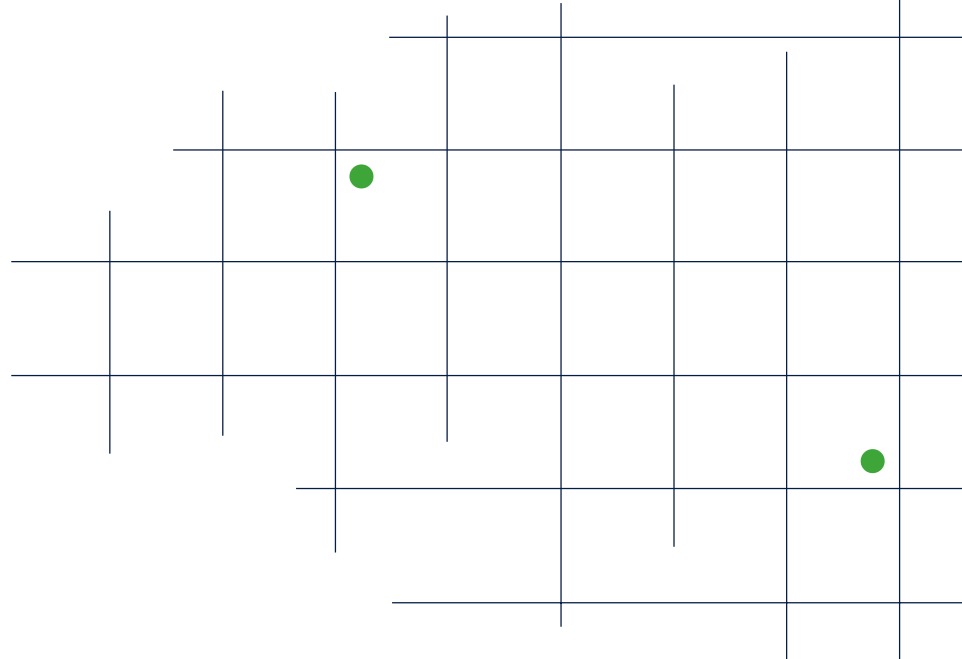
The NCEMT's experience with IPTs is a case study in success. Benefits include being able to identify potential problems early in the development process and to

engage key stakeholders early so that false starts are avoided, risk is reduced, costs are contained, and implementation is assured.

For example, the IPT that assembled to develop a combination of powder production, consolidation, and forming technologies to produce AE1107C Engine turbine disks included Rolls-Royce Corporation (engine manufacturer), Special Metals Corporation (powder producer), Ladish Co., Inc. (isothermal forging vendor), and Concurrent Technologies Corporation (CTC) (technology assessor and project manager). The AE1107C engine powers the V-22 tilt rotor helicopter. The team successfully produced P/M Udimet-720LI (Stage 3) turbine disks, which underwent successful LCF spin testing over 100,000 cycles. This was achieved by key improvements in technology, including high-yield production of -270 Mesh Udimet-720 powder, confirming acceptability of the 3:1 extrusion

ratio for hot isostatically pressed (HIPed) billets, using aggressive forged shapes to reduce weight, and validation of a two-step ultrasonic inspection concept. The use of P/M material reduces the "buy-to-fly" weight of the disks by about 25 percent and improves ultrasonic inspectability by a factor of 40. Considering both military and commercial usage of the AE engines, the verified cost avoidance is 17 percent; a further reduction of from 5–10 percent is achievable if selective ultrasonic inspection is implemented.

The NCEMT assembled an IPT to verify and demonstrate performance of advanced MIL-100S gas metal arc welding (GMAW) consumables. This team includes Newport News Shipbuilding, Electric Boat Corporation, Latrobe Steel, ESAB, and the Naval Sea Systems Command (NAVSEA) technical community. By reducing the preheat and postheat requirements and permitting wider operational



welding envelopes for fabrication of Naval ships with HY and HSLA steels, the team expects to achieve significant cost avoidance: up to \$13 million per aircraft carrier and \$5 million per submarine. A Navy Working Group that includes NAVSEA, Navy laboratories, private shipbuilders, welding consumable manufacturers, university researchers, and the NCEMT has overseen the technical work and is poised to transition the project results in the fabrication of the New Attack Submarine (NSSN) and the CVN 76.

A Navy IPT recommended that a palletized Carriage, Stream, Tow, and Recovery System (CSTRS) be developed for the CH-60 helicopter. The NCEMT accepted the job at

the request of the Naval Air Systems Command and the Program Office for Mine Warfare Airborne Mine Defense. As a result, the NCEMT has developed a pre-production prototype CSTRS for Organic Airborne Mine Counter Measure Systems. This palletized CSTRS is lighter, more compact, and removable to accommodate the Navy's next-generation helicopter.

When the NCEMT was tasked with optimizing HSLA-65 welding procedures for fabrication of Naval ship structures, the NCEMT worked with NAVSEA, Naval Surface Warfare Center, and Newport News Shipbuilding in Virginia. The technology that was developed as a result of this project will be

implemented on future aircraft carriers, surface combatants, submarines, and surface ships. As detailed later in this annual report, this project enables the use of HSLA-65 steel in applications that increase strength, improve performance, and significantly reduce costs.

Together, IPTs are creating advanced processes that enable the cost-effective production of superior quality weapons systems components. They are developing new ways to lower acquisition costs and reduce maintenance expenses over the life cycle of parts. Moreover, they are ensuring defense readiness and maintaining the U.S. Navy's unparalleled combat capability. ●



# Ships



Consistent with the Navy's need to reduce acquisition and life-cycle costs, the NCEMT is working on a variety of projects to ensure the availability of proven, affordable technology capable of withstanding military-unique demands.

As a result, the primary hull material in U.S. Naval surface ships will be thinner, lighter, and considerably stronger. Higher-strength castings and forgings are now available for processing Naval components. These breakthroughs and others, as detailed in this annual report, enable the NCEMT to continuously expand its service to the Navy and help improve U.S. defense readiness.

## **Maximizing Performance of Lower-Cost Commercial Steel**

U.S. Naval ships have traditionally been constructed using a combination of military-specification and commercial-specification steels. Military specification steels were used for critical applications because commercial steels might not perform adequately under certain circumstances. The NCEMT, in a collaborative effort with the Navy, commercial shipyards, and domestic steel producers, is maximizing the performance of commercial steels to assist government and industry in meeting cost-reduction and quality goals in order to deliver the best steel at the best price.

The NCEMT created a new testing procedure—the Fracture Toughness Structural Performance Element (FTSPE) Test—by using Finite Element Analysis results of the LPD 17 hull structure. This test procedure was used to evaluate the performance of selected commercial steels and confirm their ability to meet Navy requirements. This was the first time the NAVSEA Fracture Toughness Review Process for Metals in Critical Non-Nuclear Shipboard Application (FTRP) was applied to a Naval material.

As a result of the NCEMT's analysis, the Navy is removing HY-80 crack arrestors and is implementing normalized and control-rolled

American Bureau of Shipping Grade EH-36 steel plate as the sole primary hull material for the LPD 17-class Amphibious Transport Ships. This will result in an \$8.8-million acquisition cost savings, with additional life-cycle cost savings expected. By applying the results of this effort on remaining DDG 51 AEGIS Destroyers and future DD 21 Destroyers, the Navy is expected to save an additional \$13.5 million.

### **Reducing Life-Cycle Costs with Enhanced Welding Procedures**

The NCEMT is working with NAVSEA to optimize welding procedures for commercially available consumables to provide reliable performance of HSLA-65 welded joints for ship construction. HSLA-65 has weldability equal to or better than conventional higher-strength steel. Because of its reduced plate thickness, increased design stress levels, improved weldability, and weld quality, HSLA-65 will reduce acquisition and life-cycle costs and improve performance. HSLA-65 will be used on the CVN-77 to save weight and increase strength and toughness in certain areas. Full utilization in design of the higher-strength capability of HSLA-65 could eliminate at least 4,300 tons of weight. Newport News Shipbuilding estimates \$10,000 per ton cost avoidance—a potential \$43 million in life-cycle cost avoidance for the CVNX2.

### **Eliminating Costly Preheats for Forgings and Castings**

To further reduce the weight and

enhance the performance of surface ships, the NCEMT is evaluating high-strength castings and forgings. The goal of this effort is to decrease Naval ship fabrication and repair expenses by eliminating costly rework and possible in-service failures due to hydrogen-assisted cracking in high-strength steel castings and by eliminating preheat of high-strength steel castings and forgings during welding. Currently, the cost of preheating prior to welding is about \$1,500 per ton. Considering that combat ships require about 1,100 tons of HY-80/100 castings and forgings per year, the Navy could realize up to \$1.65 million in cost savings annually.

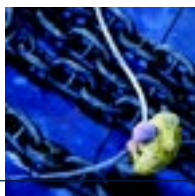
As a result of this effort, the NCEMT has already transferred valuable technology to the Navy, shipyards, and foundries, demonstrating how to determine the optimum thermal soaking treatments to mitigate hydrogen embrittlement and hydrogen-assisted cracking in high-strength steel castings. Although testing continues, early conclusions indicate that both the HSLA-100 composition plate without niobium and the SP-7 composition have promise for meeting MIL-S-23009C forging requirements for sections up to five inches thick.

### **Improving Refrigeration for Minesweeping and Ceramics for Sonar Applications**

Under a prior Rapid Response initiative, the NCEMT successfully established the feasibility of rolling neodymium (Nd) metal into ridged tapes or ribbons, which increased

refrigeration capacity. In 2000, the NCEMT completed another step in the Navy's drive to improve efficiency of the compact refrigerators (cryocoolers) used to cool superconducting magnets for shallow-water minesweeping. A process was developed that produced long lengths of ridged Nd ribbon. This ribbon nearly matched the performance of Nd spheres as a regenerator, yet had only 45 percent of the surface area available for heat transfer as compared to Nd spheres. The use of ridged ribbon also yielded a 40-percent reduction in pressure drop across the regenerator medium as compared to that of the spheres.

The NCEMT is also working to improve the mechanical reliability of lead magnesium niobate (PMN) ceramics for transducer applications. The high-energy density transduction material is the critical enabling technology for advanced active sonars such as the Lightweight Broadband Variable Depth Sonar. To date, the NCEMT has acquired PMN plates from four manufacturers, machined them into samples, and provided samples and fixtures from the manufacturers to the Naval Undersea Warfare Center (NUWC), Division Newport for electromechanical property testing. The NCEMT has successfully completed four-point flexure testing and fracture analysis on two samples, developed a procedure for compression testing with acoustic emission, and designed an apparatus for measuring basic electrostrictive properties. ●



# Submarines



Submarine innovation promises to dramatically improve as the Submarine Force enters its second century of service. U.S. submarines have attained a superior balance of stealth, endurance, ability, and firepower, yet the limited volume of hulls results in relatively smaller inventory, weapon, and sensor payloads as compared to surface ships. The NCEMT is developing, testing, and verifying new technology that will help the Navy reverse this historic limitation.

In 2000, the NCEMT completed a project that enables U.S. shipbuilders to correctly select the appropriate manufacturing process parameters for the fabrication of

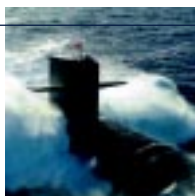
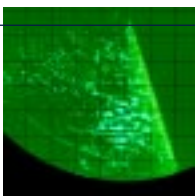
lighter-weight, lower-cost, non-pressure hull (NPH) assemblies that either improve maneuverability or increase the payload capacity of submarines. This success is an extension of prior NCEMT work, which led to the use of undermatched welding technology for the HY-100 pressure hull of the New Attack Submarine (NSSL) at an estimated savings of \$3 million per hull.

To enable the broader use of cost-effective undermatched welding technology in Naval structures, the NCEMT created a computer model—the Manufacturing Process Selection Design Tool—that assists shipbuilders in calculating design

criteria to optimize weld assemblies. By providing a better understanding of the interrelation of manufacturing process, structural performance, constraint, loading, and weldment type, this design tool gives shipbuilders a foundation on which to exploit new manufacturing processes and technology.

Technology transfer has already begun with Electric Boat Corporation in Connecticut—the shipyard that is building next-generation (Virginia Class) submarines.

In addition, the NCEMT is evaluating a new material that will make fasteners stronger and more



reliable while significantly reducing life-cycle costs. The high-strength cobalt alloy MP-159 fasteners are expected to successfully replace problematic fasteners that currently must be replaced about every three years due to corrosion.

Fasteners made of MP-159 are expected to last for the lifetime of the boat and have been selected for use on the NSSN. By improving the durability of the boat's fasteners, the Navy expects to reduce annual costs by \$800,000 per submarine.

The cost of building submarines can also be reduced by changing weld preheat and postheat requirements and expanding range-of-energy input when welding HY and HSLA steels. Currently, GMAW consumable (MIL-100S), which is used to join HY and HSLA steels in Naval ship construction, requires a significant amount of preheat and postheat to ensure resistance to hydrogen-assisted cracking. These temperature limitations slow production and increase the cost of ship construction.

A previous NCEMT project produced alternative GMAW consumable compositions that were capable of meeting the strength and toughness requirements for current MIL-100S. Now, the NCEMT,

in conjunction with the Navy Working Group on the Development of Advanced High-Strength Steel Filler Materials, has produced a commercial-sized heat of the optimum composition to define operational envelope limits for advanced MIL-100S weld wire composition for HY and HSLA steels. Under extreme conditions, these consumables are proving to be more resistant to hydrogen-assisted cracking. By implementing this advanced technology, the Navy expects a cost avoidance of \$5 million per submarine and \$13 million per aircraft carrier.

Finding a better way to fabricate heavy-gage plates will also reduce submarine costs. The NCEMT worked with Bethlehem Lukens Plate on a project to improve manufacturing processes for one- to six-inch thick HY-100 and HSLA-100 plates used in both submarines and aircraft carriers. Survivability and high performance are essential because these plates are used in structures that resist shock, blast, and ballistic loading.

To this end, the NCEMT has recommended new, cost-effective processing practices that will produce large, heavy-gauge HY-100 steel plates with improved through-thickness ductility and HSLA-100



steel plates with minimum carbon segregation. Avoiding the use of forgings in critical structures for submarines saves about \$100,000 per NSSN. Eliminating the preheat of HSLA-100 steels with a 1-1<sup>5</sup>/<sub>8</sub>-inch thickness can create up to \$4.6 million in savings for CVN-77.

Working together, the U.S. Navy, shipbuilders, and the NCEMT are optimizing manufacturing practices, reducing long-term costs, and making the best products and processes even better. ●



# Aircraft



The NCEMT is contributing to the development of advanced technology solutions for such renowned defense projects as the Joint Strike Fighter and the CH-60S helicopter. These next-generation aircraft must be affordable, reliable, and capable of meeting the nation's strategic initiatives well into this, the 21<sup>st</sup> Century.

Forged components, such as airfoils, cases, integrally bladed rotors, rings, and shafts, comprise almost 32 percent of the cost of aerospace engines and airframes. As a participant in the Air Force/Navy Forging Supplier Initiative program, the NCEMT is working to help reduce the acquisition costs

of forged aerospace components by 35–40 percent. In Phase I of the program, the NCEMT supported teams led by two original manufacturers: Pratt & Whitney and GE Aircraft Engines. The technical areas in which the NCEMT conducted research and development activities were modeling of precipitation phenomena in Ni-based alloys during heat treatment, characterization of die-workpiece interface in hot forging, ring-rolling software development, and modeling of phase changes in Ti-6Al-4V during heat treatment.

To date, the efforts of the NCEMT and its subcontractors have

resulted in FEA user-subroutines for predicting the secondary precipitation in Udimet-720LI and Rene-88DT and phase transformation phenomena in Ti-6Al-6V during heat treatment. These are two quick analysis tools for simulating the process of ring rolling and an advanced friction model to better represent the die-workpiece interface during hot forging. The program team, now led by Pratt & Whitney in Phase II, anticipates a cost savings of as much as \$1.6 billion for the Joint Strike Fighter.

Independently, the NCEMT has designed, manufactured, and is testing a reliable, cost-effective





pre-production prototype Carriage, Stream, Tow, and Recovery System (CSTRS) for Organic Airborne Mine Counter Measure systems. The new technology is critical to the Navy's ability to complete airborne mine countermeasures and other missions using next-generation helicopters.

The Navy plans to replace the aging, expensive-to-operate MH-53 helicopter with the multi-use CH-60 Nighthawk. To accommodate the Nighthawk, the CSTRS must be lighter, smaller, and removable. The NCEMT is ensuring that it will be.

The NCEMT is creating lower-cost, higher-quality superalloy turbine disks through enhanced powder metallurgy (P/M) processing. As compared with the cast/wrought processing currently in use, enhanced P/M processing combines hot isostatic pressing of ultrafine metal powders, extrusion, and isothermal forging. Based on a Navy estimate, the enhanced technology is expected to reduce the cost of the AE1107C superalloy turbine disks used on the Navy V-22 helicopter by \$19 million.

Only high-performance materials qualify for use in jet engine components. The NCEMT is

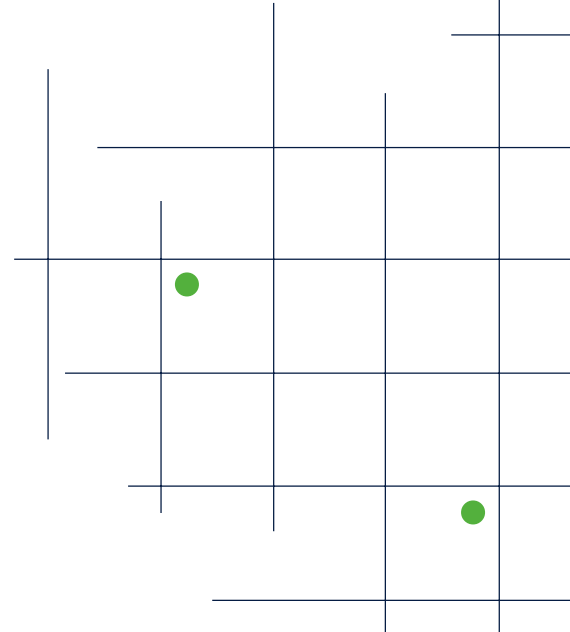


working to ensure that titanium alloys used in the production of these components are of unquestionable quality, defect free, and reliable under even the most extreme conditions.

By developing an innovative process-modeling tool for the plasma arc cold hearth melting (PAM) process, engineers at the NCEMT expected to achieve a 50-percent increase in the production rate of premium-quality titanium alloy ingots. As production time decreases, so will procurement costs. The results of this effort have already been implemented at titanium producers, such as AllVac in Monroe, North Carolina, who

have confirmed their effectiveness. Lower-cost, higher-quality titanium alloys should first impact the F404 and F414 engines for F/A-18 by the fourth quarter of 2001.

These and other projects continue to ensure the transfer of exciting new technological breakthroughs as the NCEMT works with its government and industrial partners to achieve U.S. Naval readiness objectives while significantly reducing costs. ●



# Missiles/Ordnance



From the ability to provide long-range surface fire support and precision land attack, through area and theater ballistic missile defense systems, to advanced sonar systems, the world's most sophisticated defense program will continue to be the world's most capable. The NCEMT is working on a number of projects to ensure defense readiness through affordable, improved manufacturing processes for missile and ordnance components.

For example, the U.S. Marine Advanced Amphibious Assault Vehicle (AAAV) requires a high degree of survivability, mobility, lethality, and reliability—all at a

minimal weight. To meet these requirements, the NCEMT was tasked with developing improved fabrication technology and corrosion protection methods for the AAAV's aluminum armor plate.

The material of preference for these plates is made of high-strength AL2519-T87. However, there are several key issues that must be resolved before full implementation. These include that the material is available only as plates, the need for key mechanical data, and the need for corrosion protection. The NCEMT's 18-month study produced an impressive list of accomplishments, including the

identification of promising surface treatments for AL2519-T87 that will improve its resistance to seawater corrosion. Process development, aided by finite element modeling, determined the optimum conditions for making extrusions and closed die forgings such as for those found on the sprocket carrier on the AAAV. Furthermore, the NCEMT has enabled the simplification of the structural design by demonstrating the use of friction stir welding, which will lead to significantly enhanced fabrication and reduced manufacturing time and rework. Full implementation of AL2519-T87 is expected to save \$16–\$22 million in the production and fielding of the AAAV.

The U.S. DOD is dedicated to developing new, highly mobile, survivable combat vehicles that utilize lightweight design. In support of this effort, the U.S. Army has enlisted the NCEMT's expertise for the Combat Vehicle Research (CVR) program. This new program concentrates on integrating advanced lightweight alloys and technologies into emerging vehicle platforms such as the Army's Crusader (self-propelled howitzer), as well as other developmental programs such as Future Scout, Future Combat Systems, and the Composite Armored Vehicle. CVR focuses on the use of lightweight armor and structural materials such as aluminum-lithium and titanium alloys. Advanced processing technologies such as Friction Stir Welding and improved hearth melting are being applied to increase system performance while lowering production costs.

A joint project with the British Navy is also resulting in more affordable weapons systems. The NCEMT was asked to evaluate the design and manufacture of British Aerospace components. The goal is to develop a material and a manufacturing process that will reduce the weight and the cost of the high-temperature

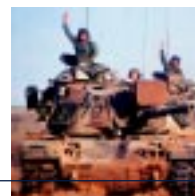
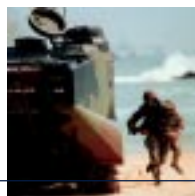


lightweight radial manifold, an essential component of the Surface Ship Torpedo Defense Concept 1 Dispenser.

The NCEMT anticipates a reduction in the manufacturing cost from \$17,000 per manifold system to approximately \$1,000 each. The product's weight will decrease from 2.9 Kg to 1.1 Kg. The NCEMT team is currently manufacturing prototype components that will be transported to British Aerospace for final testing.

In another project, the NCEMT is developing cost-effective manufacturing technology for aluminum stabilized NbTi

superconductors. The U.S. Navy requires large-scale, lightweight aluminum stabilized superconducting magnets for the In-Stride Minesweeping System. Until now, the magnet systems were excessively heavy. After investigating several alternatives, the NCEMT selected extrusion as the process for cladding high-purity aluminum onto superconductive core wire. The improved manufacturing technology will result in a 30–40-percent cost savings as compared to the aluminum cladding process it replaces. The aluminum stabilized superconductor will be 40–50 percent lighter and have ten times the thermal stability of the prior system. ●



# Leveraging Capabilities



The old adage about reinventing the wheel takes on a new urgency at the NCEMT. NCEMT scientists, engineers, and other professionals avoid reinventing the wheel by tapping into the nation's technology base, thus ensuring the availability, reliability, and affordability of products and processes. The NCEMT's goal is to make the best even better to meet U.S. Naval needs. Wherever possible, it leverages proven technologies, disseminating them for adoption within the U.S. defense industrial base.

By transitioning appropriate science and technology quickly to the broadest possible audience, the

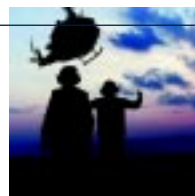
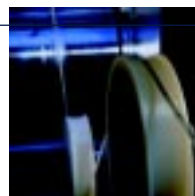
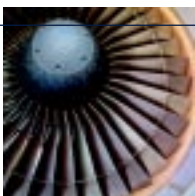
NCEMT lowers initial development costs. Manufacturers who spend less time reinventing the wheel reduce their own costs. The NCEMT ensures that capable new technologies can be adopted cost-effectively and successfully with fewer obstacles. Leveraging makes good business sense and is a critical factor in maintaining defense readiness. A few examples follow.

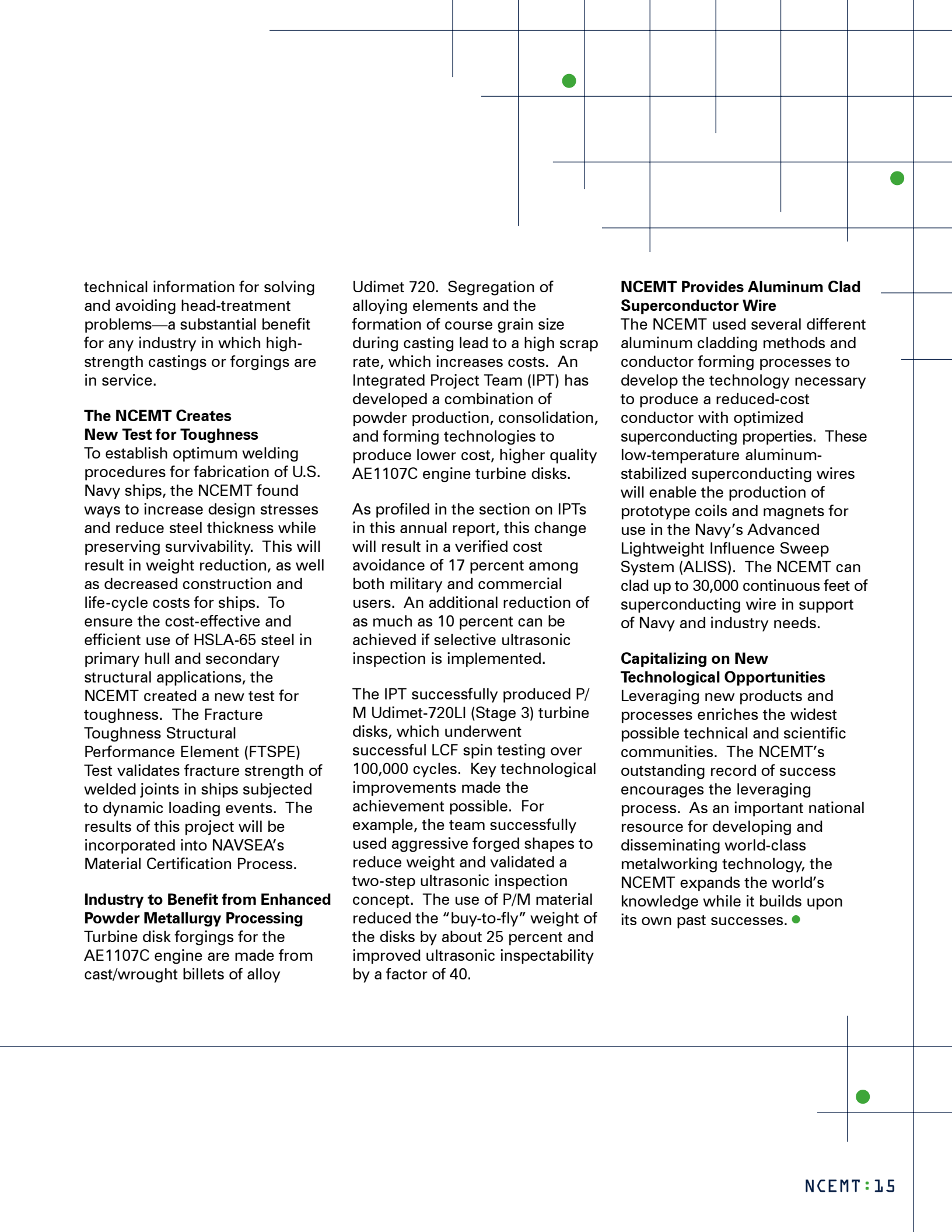
## **New Heat-Treatment Tool Developed**

The NCEMT developed a new heat-treatment modeling capability as a result of the Optimized Commercial Steels for Naval Surface Ships project. This technology—which uses commercially available

software to analyze the heat treatment process—will benefit the Navy, commercial foundries, and heat treaters.

Numerical analysis techniques used in conjunction with Computation Fluid Dynamics (CFD) software was developed and validated using a gas-fired furnace. Results show that this software can accurately predict temperatures throughout a component during heating. CFD software applied to the heat-treatment process requires significant user knowledge and computational resources and will require further hands-on experience. However, this technology will ultimately provide





technical information for solving and avoiding heat-treatment problems—a substantial benefit for any industry in which high-strength castings or forgings are in service.

### **The NCEMT Creates New Test for Toughness**

To establish optimum welding procedures for fabrication of U.S. Navy ships, the NCEMT found ways to increase design stresses and reduce steel thickness while preserving survivability. This will result in weight reduction, as well as decreased construction and life-cycle costs for ships. To ensure the cost-effective and efficient use of HSLA-65 steel in primary hull and secondary structural applications, the NCEMT created a new test for toughness. The Fracture Toughness Structural Performance Element (FTSPE) Test validates fracture strength of welded joints in ships subjected to dynamic loading events. The results of this project will be incorporated into NAVSEA's Material Certification Process.

### **Industry to Benefit from Enhanced Powder Metallurgy Processing**

Turbine disk forgings for the AE1107C engine are made from cast/wrought billets of alloy

Udimet 720. Segregation of alloying elements and the formation of coarse grain size during casting lead to a high scrap rate, which increases costs. An Integrated Project Team (IPT) has developed a combination of powder production, consolidation, and forming technologies to produce lower cost, higher quality AE1107C engine turbine disks.

As profiled in the section on IPTs in this annual report, this change will result in a verified cost avoidance of 17 percent among both military and commercial users. An additional reduction of as much as 10 percent can be achieved if selective ultrasonic inspection is implemented.

The IPT successfully produced P/M Udimet-720LI (Stage 3) turbine disks, which underwent successful LCF spin testing over 100,000 cycles. Key technological improvements made the achievement possible. For example, the team successfully used aggressive forged shapes to reduce weight and validated a two-step ultrasonic inspection concept. The use of P/M material reduced the “buy-to-fly” weight of the disks by about 25 percent and improved ultrasonic inspectability by a factor of 40.

### **NCEMT Provides Aluminum Clad Superconductor Wire**

The NCEMT used several different aluminum cladding methods and conductor forming processes to develop the technology necessary to produce a reduced-cost conductor with optimized superconducting properties. These low-temperature aluminum-stabilized superconducting wires will enable the production of prototype coils and magnets for use in the Navy's Advanced Lightweight Influence Sweep System (ALISS). The NCEMT can clad up to 30,000 continuous feet of superconducting wire in support of Navy and industry needs.

### **Capitalizing on New Technological Opportunities**

Leveraging new products and processes enriches the widest possible technical and scientific communities. The NCEMT's outstanding record of success encourages the leveraging process. As an important national resource for developing and disseminating world-class metalworking technology, the NCEMT expands the world's knowledge while it builds upon its own past successes. ●



# Technology Transfer Activities



Paramount to the NCEMT mission: transferring what is learned to applicable civil-military industrial audiences. It's all about extending the benefits of its progress, promoting industrial advancement, and leading the drive for cost-effective manufacturing technologies.

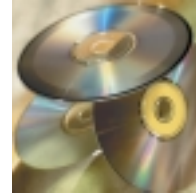
The NCEMT begins planning for technology transfer at the start of each new project. This process involves identifying key Navy, government, and industrial organizations who may benefit from anticipated outcomes. As the project concludes, NCEMT's experts work one-on-one with the end user to transition technology.

The NCEMT also conducts broad-based information dissemination through seminars, exhibits, project demonstrations, interactive electronic databases, publications, and videos.

Following are highlights of selected NCEMT technology transfer activities:

**Manufacturing Technology for Aerospace Materials:** Managers and technical personnel of government agencies and weapons systems program offices were among those who came to a technology demonstration and information exchange hosted by the NCEMT in July in Arlington,

Virginia. Others taking part in the exchange were manufacturers and suppliers of aerospace systems, materials, and components. The program was designed to give the members of the aerospace community an opportunity to exchange ideas on advanced aerospace technologies and manufacturing processes. Technical sessions focused on casting technologies, forming technologies, and process and material selection. Participants shared their requirements for advanced materials and production processes and provided feedback on further applications for NCEMT-developed technologies.



Speakers presented the Navy's and the DOD's current and future technology needs and an industrial perspective.

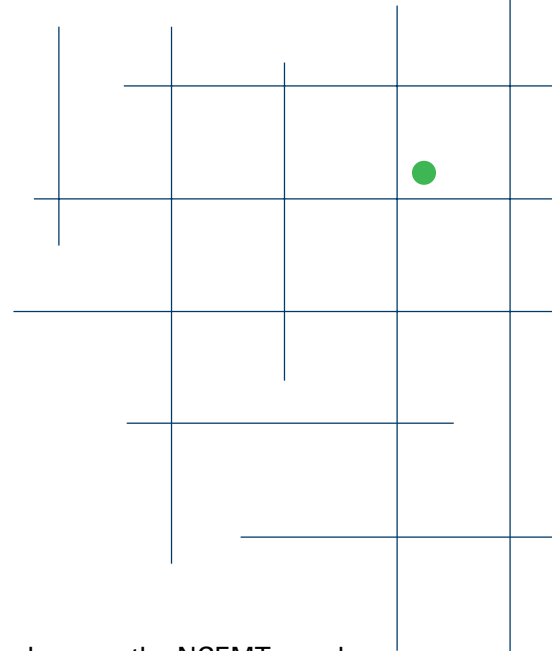
**Shipbuilding Technologies 2000:** Reducing total ownership costs of Naval ships while enhancing the competitiveness of the American shipbuilding industry was the objective of a joint Centers of Excellence information exchange sponsored by the NCEMT. The event enabled members of the domestic shipbuilding community and the Navy MANTECH Program to swap technical information on shipbuilding processes and technologies. This was the first time all MANTECH Centers of Excellence were involved in the exchange. The National Shipbuilding Research Program also took part. Industrial presentations centered on completed and ongoing technical projects and industry needs and challenges. Panel discussions addressed the technical problems encountered by American shipbuilders and how MANTECH-funded developments can be accessed to resolve those problems. The two-day exchange of information, attended by more than 150 people, was held in September in New Orleans, Louisiana.



**Enhanced P/M Project Demonstration:** Results of the Enhanced P/M Project were demonstrated in August at Concurrent Technologies Corporation (CTC) in Johnstown, Pennsylvania. Summaries of their respective technical work were presented by Special Metals Corporation, LadishCo., Inc., Rolls-Royce Corporation, and the NCEMT. The technologies developed were demonstrated by the production and testing of Udimet 720 (Stage 3) turbine disks for the AE1107C engine of the V-22 Osprey tiltrotor aircraft.

In addition to sponsoring workshops and information

exchanges, the NCEMT may be tapped by industrial and governmental organizations to foster and facilitate the implementation of advanced materials and manufacturing processes in the industrial base. For key engineering knowledge bases, technologists can access the NCEMT Internet Information Server via the NCEMT website at [www.ncemt.ctc.com](http://www.ncemt.ctc.com). ●





National Center for Excellence in  
Metalworking Technology

Operated by



For the U.S. Navy  
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Cover: Hand signals from ship during  
an underway replenishment (UNREP)  
Cover: Lieutenant Commander during  
flight operations

Pg. 8: USS Maine (SSBN 741), main  
control watch, and Seawolf (SSN 21)

Pg. 9: Navigating SSN 705 out to sea

Pg. 11: Flight deck crewman prepares  
to chock & chain a CH-46D helicopter

Pg. 13: Sea Sparrow missile launch

Pg. 14: Airmen signal a landing on  
the flight deck



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